

APPLICATION FOR A UNITED STATES PATENT

for

AN APPARTUS AND A METHOD TO PROVIDE HIGHER
BANDWIDTH OR PROCESSING POWER ON A BUS

by

CHAKRAVARTHY KOSARAJU

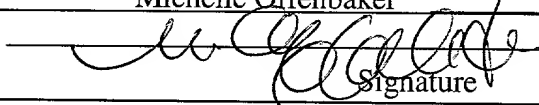
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**AN APPARTUS AND A METHOD TO PROVIDE HIGHER BANDWIDTH OR
PROCESSING POWER ON A BUS**
FIELD OF THE INVENTION

[0001] This invention generally relates to changing the number of ports linked between a device and a processor. More particularly this invention relates to an apparatus and method capable of changing the number of ports linked between a device and a processor without changing the architecture in the processor.

BACKGROUND OF THE INVENTION

[0002] Joining several processors in parallel increases processing capacity. Typically, any number from two to eight processors may be joined in parallel. Generally, multiple parallel processors are joined together on a shared bus. Figure 1 illustrates a four processor (4P) architecture used in conjunction with a shared bus. Four processors, Processor 1, Processor 2, Processor 3, and Processor 4, connect to a shared bus, which in turn connects to the Northbridge chipset. The Northbridge chipset further connects to the Southbridge chipset and external memory. For example, a Pentium™ processor may employ the shared bus architecture illustrated in figure 1. However, a point-to point architecture, typically, provides a higher bandwidth than does a shared bus architecture.

[0003] In a shared bus architecture, multiple devices all share the same bus and must follow an order and protocol to use the bus. In contrast, a point-to-point bus architecture provides an uninterrupted connection between two separate devices. Thus, in general, a point-to-point bus creates a higher bandwidth between two separate devices. A higher bandwidth can have the

beneficial effect of yielding an increased performance from a single processor or group of processors. For example, if a 48-bit connection exists between two devices, then transactions occur between the two devices three times faster than if only a 16-bit connection exists between the two devices. However, a point-to-point bus architecture may have a disadvantage because the architecture provides an uninterrupted connection between two separate devices. Thus, if at any given time, light transfers of information occur between the two devices, then the excess bandwidth capacity is essentially wasted.

[0004] For example, if a customer is using his or her computer system to run both a workstation application and a server application, then the customer may not be achieving peak performance from the hardware in his computer system. In a server application a heavy exchange of information occurs between processors. Thus, the manufacturer may create a high bandwidth connection between each processor in the system. Yet, if for example a customer wants to use a computer system for an application, which involves a heavy exchange of information between each processor and a chipset, such as a workstation application, then the manufacturer creates a high bandwidth connection between each processor and the chip in the system. However, if the customer has a computer system which has a high bandwidth connection between the processor(s) and the chipset, but chooses to currently run a server application on this system, then the customer may suffer poor performance from the server application and waste the excess bandwidth between the chipset and processor(s).

[0005] Further, manufacturers may build different versions of a processor: to optimally service either a work station or a server; or to perform satisfactorily for most work station or server applications. Typically, a processor is hardwired to the other processors and components, such

as chipsets, in the system. A manufacturer may create a high bandwidth connection between two processors or a processor and a chipset by dedicating a number of port establishing the connection between these two devices. The manufacturer creates the chip with an expectation that a hardwire connection to exist between the two devices. The manufacturer presets the processing component of the processor to know that these ports are dedicated between the two devices.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The drawings refer to the invention in which:

[0007] figure 1 illustrates a four processor (4P) architecture used in conjunction with a shared bus;

[0008] figure 2 illustrates an embodiment of a processor having an arbiter, a protocol layer, a buffer layer, and an information transfer layer;

[0009] figure 3 illustrates a two processor point-to-point architecture having a 16-bit point-to-point connection between: 1) an input-output component and the first processor; as well as 2) the input-output component and the second processor;

[0010] figure 4 illustrates a two processor point-to-point architecture having a 32-bit point-to-point connection between: 1) the input-output component and the first processor; as well as 2) the input-output component and the second processor;

[0011] figure 5 illustrates a four processor point-to-point architecture having a 16-bit point-to-point connection between an input-output component and each of the four processors;

[0012] figure 6 illustrates an embodiment of an eight processor point-to-point architecture comprised of four pairs of processors linked to a corresponding bridge and each bridge connected to a chipset;

[0013] figure 7 illustrates an embodiment of the arbiter controlling the inbound signal pathways in an embodiment of the information transfer layer;

[0014] figure 8 illustrates an embodiment of the arbiter controlling the inbound signal pathways in an embodiment of the buffer layer;

[0015] figure 9 illustrates an embodiment of the arbiter controlling the outbound signal pathways in an embodiment of the buffer layer; and

[0016] figure 10 illustrates an embodiment of the arbiter controlling the signal pathways in an outbound information transfer layer.

[0017] While the invention is subject to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and will herein be described in detail. The invention should be understood to not be limited to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention.

DETAILED DISCUSSION

[0018] A person skilled in the art will appreciate that various deviations from the described embodiments of the invention are possible and that many modifications and improvements may be made within the scope and spirit thereof. For example, in several described embodiments specific clock speeds, specific number of data bits, specific number of layers, a specific number of components, etc. are used within this description to illustrate embodiments of the invention. However, a person skilled in the art will appreciate that embodiments of this invention specifically include various deviations from the specific number given in a particular embodiment described herein for illustrative purposes.

[0019] An arbiter may be used with a processor in a point-to-point architecture to allow a customer to change the number of ports linked between a processor and a device external to the processor. A point-to-point bus architecture provides an uninterrupted connection between two separate devices. Generally, a packet based protocol transfers information in a point-to-point bus architecture. The arbiter may alter the number of ports linked between the processor and the device exterior to the processor by changing one or more internal signal pathways in the processor without changing a physical component layout in the processor. In an embodiment, the manufacturer or the customer may change the number of ports linked between the two devices to increase the bandwidth between the devices. In an embodiment, the manufacturer or the customer may add additional processors linked to a device by changing the number of ports linked between a first processor and the device exterior to the first processor.

[0020] Figure 2 illustrates an embodiment of a processor **200** having an arbiter **202**, a protocol layer **204**, a buffer layer **206**, and an information transfer layer **208**. In one embodiment, the

processor **200** has an arbiter **202** and three layers, the protocol layer **204**, a buffer layer **206** such as one or more link layers **210**, and an information transfer layer **208** such as one or more physical layers **212**. The arbiter **202** changes the signal pathways within the physical layer **212** and link layer **210** without changing the physical component layout in the processor **200**. The physical layer **212** carries out the actual physical transfer of information to and from other devices. The link layer **210** performs liaison functions between the higher functions of the protocol layer **204** and the physical layer **212**. The protocol layer **204** processes requests, responses, and data transfers.

[0021] In an embodiment, the arbiter **202** may be internal or external to the processor **200**. In an embodiment, a single arbiter **202** controls the signal pathways in all the layers of the processor **200**. In an alternative embodiment, multiple arbiters **202** exist to control the signal pathways. The arbiter **202** may be a combination of hardware and software. The arbiter **202** may have several functions such as sending an enable/disable signal to one or more signal pathway switching devices and sending a signal to change various clocking speeds. The buffer layer **206** may have one or more inbound signal pathways. The buffer layer **206** may have one or more outbound signal pathways. The information transfer layer **208** may have one or more inbound signal pathways. The information transfer layer **208** may have one or more outbound signal pathways.

[0022] Figure 3 illustrates a two processor point-to-point architecture **300** having a 16-bit point-to-point connection between: 1) an input-output component **302** and the first processor **304**; as well as 2) the input-output component **302** and the second processor **306**. A first

processor **304** having four 16-bit ports **308, 310, 312, 314** connected to the processor may have three 16-bit ports **308, 310, 312** connected to a second processor **306** and one 16-bit port connected **314** to the input-output component **302**. In an embodiment, the input-output component maybe a bridge, a memory, a chipset or similar component. Thus, a 48-bit bandwidth connection exists between the first processor **304** and the second processor **306**. Further, the first processor **304** and the second processor **306** have a 16-bit bandwidth connection to the input-output component **302**. The arbiter can change the signal pathways in the first processor **304** such that the processor now has two 16-bit point-to-point (32-bit) connections to the second processor **306** and a 32-bit connection to the input-output component **302**.

[0023] Figure 4 illustrates a two processor point-to-point architecture **400** having a 32-bit point-to-point connection between: 1) the input-output component **402** and the first processor **404**; as well as 2) the input-output component **402** and the second processor **406**. A first processor **404** having four 16-bit ports **408, 410, 412, 414** connected to the processor may have two 16-bit ports connected to a second processor **406** and two 16-bit ports connected to the input-output component **402** such as a chip set. Thus, a 32-bit bandwidth connection exists between the first processor **404** and the second processor **406**. Further, the first processor **404** and the second processor **406** have a 32-bit bandwidth connection to the input-output component **402**. In the 32-bit mode as compared to 16-bit mode, the bandwidth between the input-output component **402** and the first processor **404** as well as the input-output component **402** and the second processor **406** has effectively doubled. Bandwidth is the total amount of information that can be transferred within a given time period between two devices. In 16-bit mode, eight clock cycles

must occur to transfer eight 16-bit packets (128 bits) of information between each processor and the input-output component. In 32-bit mode, four clock cycles must occur to transfer four 32-bit packets (128 bits) of information between each processor and the input-output component.

[0024] Figure 5 illustrates an embodiment of a four processor point-to-point architecture **500** having a 16-bit point-to-point connection between an input-output component **502** and each of the four processors **504, 506, 508, 510**. The four processors are processor 1 **504**, processor 2 **506**, processor 3 **508**, and processor 4 **510**. In an embodiment, each of the four processors **504, 506, 508, 510** employs an embodiment of the arbiter. The processors **504, 506, 508, 510** have a flexible architecture that coordinates with the arbiter to allow a variety of uses for these processors **504, 506, 508, 510**. For example, the four processor architecture **500** may be substituted with the two processor architecture employing a 32-bit connection with the input-output component **502**. Thus, the processing power of this arrangement has effectively doubled because four processors will process the data coming from the input-output component **502**. Thus, an embodiment of the arbiter allows the same input-output component **502** to work with either a two processor architecture, a four processor architecture **500** or other similar multiple processor architecture.

[0025] A programmable knob setting in a configuration register directs the arbiter to establish the customer's current desired configuration such as a 16-bit, 32-bit, or 48-bit point-to-point connection between the processor and a device exterior to the processor. In an embodiment, the device exterior to the processor may be another processor, an input-output device, a bridge or other similar device. In an embodiment, the manufacturer or the customer may program the knob

setting to establish the bandwidth connections between the processor and devices exterior to the processor. Based on the knob setting of the configuration register, the arbiter may enable and disable signal pathways within the information transfer layer and buffer layer. In an embodiment, the arbiter may change these signal pathways to increase or decrease the number of processor ports, and thus, the effective bandwidth, between a processor and another device. In an embodiment, the arbiter may change these signal pathways to increase or decrease the number of processor ports, and thus the number of processors, connected to the input-output device.

[0026] Typically, in a server, a large exchange of data occurs between a first processor and a second processor. Thus, having a 48-bit point-to-point connection between these two devices greatly decreases the time required to complete each transaction between the devices. Typically, in a work station, a large exchange of data occurs between a each processor and the input-output component. Thus, having a 32-bit or 48-bit point-to-point connection between these devices greatly decreases the time required to complete each transaction between the devices.

[0027] Figure 6 illustrates an embodiment of an eight processor (8P) point-to-point architecture 600 comprised of four pairs of processors, 602, 604, 606, 608, 610, 612, 614 and 616, linked to a corresponding bridge, 620, 622, 624, 628, and each bridge, 620, 622, 624, 628, connected to a chipset 630. A first processor 602 and a second processor 604 each have a 16-bit point to point connection with a first bridge 620. The first bridge 620 has a connection, such as a 32-bit connection, with the chipset 630. Similarly, a third processor 606 and a fourth processor 608 each have a 16-bit point to point connection with a second bridge 622. The second bridge 622 has a connection, such as a 32-bit connection, with the chipset 630. In a similar fashion, the fifth

processor **610** through eighth processor **612** eventually link with the chipset **630**. In an embodiment, the arbiter may allow the signal paths internal to each processor **602, 604, 606, 608, 610, 612, 614** and **616**, to be changed by a programmable setting. This allows a manufacturer to fabricate a single version of a processor with a generic but flexible architecture within the processor to service multiple processor platforms. Thus, in an embodiment, an arbiter linked to a processor having a single flexible architecture may be employed to service, a 2P architecture, 4P architecture, 8P architecture or other multiple processor architecture, as well as service a server application and a workstation application.

[0028] In an embodiment, the ability of the arbiter to change the allocation of internal signal paths allows a manufacturer to design and fabricate fewer versions of the same chip to service customers needs. In an embodiment, the architecture of the processor is the arrangement and component makeup of the various elements within the processor. In an embodiment, the components and elements contained within the protocol layer, the information layer and the buffer layer makeup the architecture of the processor. Those ordinarily skilled in the art will recognize the specific components illustrated in the following embodiments may be deviated from and still be within the spirit of this invention.

[0029] Figure 7 illustrates an embodiment of the arbiter **702** controlling the inbound signal pathways in an embodiment of the information transfer layer **700**. The first physical layer (SPXO) **704** has a first port **706**; nine 16-bit registers, a first register **708**, a second register **710**, a third register **712**, a fourth register **714**, a fifth register **716**, a sixth register **718**, a seventh register **720**, an eighth register **722**, and a ninth register **724**; first 64-bit register **726**; a signal pathway

switching device **728** such as a multiplexer; an embodiment of the arbiter **702**; a first time delay **709**, and a first flip flop **730**. The second physical layer (SPX1) **732** has a second port **734**; nine 16-bit registers, a tenth register **736**, an eleventh register **738**, a twelfth register **740**, a thirteenth register **742**, a fourteenth register **744**, a fifteenth register **746**, a sixteenth register **748**, a seventeen register **750**, and an eighteenth register **752**; a second 64-bit register **753**; and a second time delay **737**, and a second flip flop **756**. A multiplexer is a device that merges several low-speed transmissions into one high-speed transmission and vice versa. The configuration register **754** informs the arbiter **702** whether a particular component exterior to the processor should be a 16-bit, 32-bit or 48-bit-point-to-point connection.

[0030] If the configuration register **754** is programmed for a 16-bit point-to-point connection to the input-output component, then the arbiter **702** directs each physical layer to act independently of the other physical layers. In an embodiment of a four processor architecture for example, the first port **706** connects to a second processor and the second port **734** links up to an input-output component. The first register **708** receives an inbound 16-bit packet of information through the first port **706**. This 16-bit packet of information is sent from the first register **708** through a first time delay **709** to be stored in the second register **710**. The first register **708** receives another inbound 16-bit packet of information through the first port **706**. The first register **708** sends this second 16-bit packet of information to be stored in the third register **712**. The first physical layer **704** repeats this process until the second register **710** through the ninth register **724** are each storing 16-bit packets of information. The first signal pathway switching device **728** senses that these eight 16-bit (or 128-bits) of information are ready to be transferred to the first link layer through the first flip flop **730**. Upon the next clock cycle the 128-bits of information are

transferred to the first link layer through the first flip flop **730**. In a similar manner but using the components of second physical layer **732**, the second physical layer **732** transfers 128-bits to the second link layer. However, the 128-bits of information that are transferred to the first link layer are unrelated to the 128-bits of information that are transferred to the second link layer. Thus, in our example the first 128-bits of information come through the first port **706** from a second processor. Similarly, the second 128-bits of information come through the second port **734** from the input-output component. The arbiter **702** enables the 128-bit path in the first signal pathway switching device **728**. The arbiter **702** disables the dual 64-bit path in the first signal pathway switching device **728**. The arbiter **702** enables the first flip flop **730** and the second flip flop **756**.

[0031] If the configuration register **754** is programmed for a 32-bit point-to-point connection, then the arbiter **702** gangs two physical layers to act together. The arbiter **702** disables the 128-bit path in the first signal pathway switching device **728**. The arbiter **702** enables the dual 64-bit path in the first signal pathway switching device **728**. The arbiter **702** enables the first flip flop **730** but disables the second flip flop **756**. The arbiter **702** increases the clocking speed for the first register **708** through the eighteenth register **752** by a factor of two. The first physical layer **704** receives four 16-bit packets of information and stores the packets of information in the second register **710** through the fifth register **716**. The second physical layer **732** receives four 16-bit packets of information and stores the packets of information in the eleventh register **738** through the fourteenth register **744**. The first signal pathway switching device **728** senses that the first 64-bit register contains four 16-bit packets of information from the second register **710** through the fifth register **716**. The first signal pathway switching device **728** senses that the second 64-bit register contains four 16-bit packets of information from the eleventh register **738**

through the fourteenth register **744**. Upon the next clock cycle, the 64-bits of information from the first 64-bit register and the 64-bits of information from the second 64-bit register are transferred up to the first signal pathway switching device **728** through the dual 64-bit path. The first signal pathway switching device **728** transfers the eight related 16-bit packets of information to the first link layer. Both the device exterior to the processor and the processor transfer the eight related 16-bit packets of information as if a 32-bit point-to-point connection exists between the processor and the device. The second link layer receives no signal because the second flip flop **756** is disabled. In a similar manner, the arbiter may gang three physical layers together to create a 48-bit point-to-point connection between the processor and the device.

[0032] Figure 8 illustrates an embodiment of the arbiter **802** controlling the inbound signal pathways in an embodiment of the buffer layer **800**. The inbound signal pathway of the first link layer **804** has a first 128-bit register **806**, a first response queue **808**, a first request queue **810**, and a first signal pathway switching device **812**. The inbound signal pathway of the second link layer **814** has a second 128-bit register **816**, a second response queue **811**, a second request queue **813**, and a second signal pathway switching device **816**. The component makeup of the third link layer **818** and fourth link layer **820** are similar to the first link layer **804**. The first link layer **804** through the fourth link layer **820** feed into a fifth signal pathway switching device **822**, an embodiment of an arbiter **802**, a fifth 128-bit register **824**, a local address transaction tracker buffer (LATT) **826**, a central data management buffer (CDM) **828**, and a remote address transaction tracker buffer (RATT) **830**.

[0033] In an embodiment of the inbound buffer layer **800**, if the configuration register **832** is programmed for a 32-bit point-to-point connection, then the arbiter **802** effectively gangs two link layers together. The first link layer **804** receives the eight related 16-bit packets (128-bit) of information at twice the clock speed from the communication switching device in the first physical layer. The first link layer **804** stores the 128-bit packet of information in the first register **806**. The 128-bit packet of information is routed appropriately to either the first response queue **808** or the first request queue **810**. The arbiter **802** sends an enablement signal to the first signal pathway switching device **812**, third signal pathway switching device **834**, and fifth signal pathway switching device **822**. The arbiter **802** also sends a disable signal to the second signal pathway switching device **816** and fourth signal pathway switching device **836**. The arbiter **802** directs the fifth signal pathway switching device **822** to request data only from the first signal pathway switching device **812** and the third signal pathway switching device **834**. In 32-bit mode, the second signal pathway switching device **816** and fourth signal pathway switching device **836** receive no signal from the physical layer because the arbiter **802** disabled the second flip flop and fourth flip flop in the physical layer.

[0034] The 128-bit packets of information are transferred to the fifth signal pathway switching device **822** through the first signal pathway switching device **812** and then the third signal pathway switching device **834** in a cyclic sequential manner. In a repeating cycle, the fifth signal pathway switching device **822** requests the contents of the first response queue **808**, then the first request queue **810**, then the third response queue **838**, then the third request queue **840**, and then repeats this sequence. Every packet of information may be either a request for a command and/or data or a response to a command or data. In an embodiment, once a packet is written into a

response queue or request queue, then the information is transferred from these queues at core clock frequency. The packets of information are sent from the fifth signal pathway switching device **822** to one of the following three components. The central data management buffer (CDM) **828** stores data to be consumed by the protocol layer **840**. The remote address transaction tracker buffer (RATT) **830** stores commands from a remote device such as a request from a remote processor. The CDM **828** stores corresponding data, if any, associated with that command. Similarly, the local address transaction tracker buffer (LATT) **826** stores local commands and responses made by the processor core. The corresponding data, if any, associated with that command is stored in the CDM **828**.

[0035] If the configuration register **832** is programmed for a 16-bit point-to-point connection, then each inbound link layer **804, 814, 818, 820** acts independently. The arbiter **802** directs the fifth signal pathway switching device **822** to request information out of the eight possible sources, the corresponding request queue **810, 813, 840, 850** or the corresponding response queue **808, 811, 838, 848** in each link layer **804, 814, 818, 820**, in a cyclic sequential manner. If a particular queue is empty, then the fifth signal pathway switching device **822** automatically pulls packets out of the next queue without any penalty. In an embodiment, the packets from the four physical layers are written into the appropriate queue at 100 megahertz, if the configuration register is programmed for a 16-bit connection. The packets are written into the queues at 200 Megahertz if the configuration register **832** is programmed for a 32-bit connection. If the configuration register is configured for a 48-bit connection, then the arbiter **802** gangs three link layers together. Once the fifth signal pathway switching device **822** picks a packet of information from one of the eight possible sources, then the packet is sent to the to the protocol

layer **840**.

[0036] The inbound link layer sends responses and requests to protocol layer **840**. The protocol layer **840** alternates choosing a command from the LATT **826** or RATT **830** accompanied by data from the CDM **828**. In one embodiment, this physical information may be sent to a CPU. The information goes to the CPU to be processed and sent to the outbound bound link layer. The protocol layer **840** typically is the processing component. The protocol layer **840** typically resolves requests from other local processors and sends requests out through the physical layer. The protocol layer **840** may be responsible for functions such as ordering, conflict detection, and coherence. The protocol layer **840** may forward requests for data to the local memory controller if the request is made to local memory. The protocol layer **840** may send snoop requests to the remote nodes and other local processors. The protocol layer **840** also processes requests made through the link layer, which may come from a remote processor or an input-output component.

[0037] Figure 9 illustrates an embodiment of the arbiter **902** controlling the outbound signal pathways in an embodiment of the buffer layer **900**. The protocol layer **904** sends the processed data and commands to each outbound link layer **906, 908, 910, 912**. The protocol layer **904** delivers commands generated from itself to the LATT **914** and data, if any, corresponding to that command to the CDM **916**. The protocol layer **904** delivers responses to commands from remote devices to the RATT **918** and data, if any, corresponding to that command to the CDM **916**. If the configuration register **920** is programmed for a 32-bit point-to-point connection, then the arbiter **902** effectively enables two of the four outbound link layers. The following happens in

tracing the signal path in the first outbound link layer **906** and the second outbound link layer **908**. The arbiter **902** directs the second signal pathway switching device **922** and the fourth signal pathway switching device (not shown) to be disabled. The arbiter **902** directs the fifth signal pathway switching device **928** to request data through the first signal pathway switching device **924** and third signal pathway switching device **926** from their respective request buffer **930** or response buffer **932**. The fifth signal pathway switching device **928** alternates, in a repeating cycle, requests for bits from the request buffer **930** and the response buffer **932**. The fifth signal pathway switching device **928** also receives any data, if any, corresponding to those commands from the CDM **916**. The fifth signal pathway switching device **928** then routes the 128-bit data packet through a first time delay **933** to either the outbound response queue **936** or outbound request queue **934** located in the outbound physical layer.

[0038] One or more retry queues **938** exist in the outbound link layer. The retry queue **938** stores a duplication of the information to be transferred in case an error occurs in the transfer of the information. The retry queue **938** exists primarily in case there may be an error in the link. The retry queue **938** erases the duplicated information stored in a retry queue **938** upon receiving a confirmation of an error free transfer of information.

[0039] If the configuration register **920** is programmed for a 16-bit point-to-point connection, then the arbiter **902** directs each outbound link layer **906, 908, 910, 912** to act independently. The arbiter **902** sends a signal to enable all of the outbound link layer communication switching devices and set the clock speed to the default clock speed. The information is routed from the LATT **914**, RATT **918**, and CDM **916** through its own respective outbound link layer to the corresponding outbound physical layer. For example, the arbiter **902** directs the second signal

pathway switching device **922** to request data through the sixth signal pathway switching device **940** from the second request queue **942** and then request data through the seventh signal pathway switching device **944** from the second response queue **946**. The second signal pathway switching device **922** alternates, in a repeating cycle, requests for bits from the second response queue **942** and the second request queue **946**. The second signal pathway switching device **922** also receives any data, if any, corresponding to those commands from the CDM **916**. The second signal pathway switching device **922** then routes the 128-bit data packet through a second time delay **948** to either the second outbound response queue **950** or second outbound request queue **952** located in the outbound physical layer.

[0040] Figure 10 illustrates an embodiment of the arbiter **1002** controlling the signal pathways in an outbound information transfer layer **1000**. In an embodiment, the information transfer layer comprises one or more physical layers. The physical layer carries out the actual physical transfer of information to devices external to the processor through ports, such as a first port **1004** and a second port **1006**. Typically, one 16-bit port exists on each physical layer such as the first port **1004**. The processor transfers information between itself and a device exterior to the processor through these ports. The information signal contains information such as a request, response, or data.

[0041] In an embodiment of a two processor architecture, for example, three ports hook up to the second processor in the system, and the fourth port hooks up an input-output component such as a chip set. A first signal pathway switching device **1008** such a multiplexer receives a 128-bit packet of information from the link layer. The first signal pathway switching device **1008** reads

the 128-bit packet of information from either the response queue **1011** or the request queue **1010** at a clock speed of 100 megahertz for example. The signal output of the first signal pathway switching device **1008** is two 64-bit packets of information, a first 64-bit packet and a second 64-bit packet which are stored in the first register **1012**. After a time delay **1014**, the second signal pathway switching device **1018** reads the first 64-bit packet through the second register **1016** at twice the clock speed, 200 megahertz, of the 128-bit packet of information. The signal output of the second signal pathway switching device **1018** is two 32-bit packets of information, a first 32-bit packet and a second 32-bit packet which are stored in the third register **1020**. The clock speed of 32-bit packet of information in the third register is again doubled to 400 megahertz.

[0042] The arbiter **1002** now directs the 32-bit packet of information to take a 32-bit bypass path **1022** or a 16-bit information transfer path in the corresponding signal pathway switching devices **1026**, **1034**. The configuration register **1024** informs the arbiter **1002** whether the component exterior to the processor should be a 16-bit, 32-bit or 48-bit-point-to-point connection. In one embodiment, for example, if a 16-bit point-to-point connection exists between the processor and the input-output component, then arbiter **1002** directs each physical layer to act independently of the other physical layers. A fourth signal pathway switching device **1026** reads the 32-bit packet of information at 400 megahertz from the third register **1020** and outputs two 16-bit packets of information. A fifth signal pathway switching device **1028** reads the 16-bit packet of information at 400 megahertz from the forth register **1027** and outputs the 16-bit packet of information to the first port **1004**. The arbiter **1002** sends a signal to the sixth signal pathway switching device **1030** in the second outbound physical layer **1032**. The signal enables the 16-bit path in the fifth signal pathway switching device **1028**. The arbiter **1002**

disables the 32-bit bypass path **1022** from the fourth signal pathway switching device **1026**. The arbiter **1002** also sends a signal to the second physical layer **1032**, the sixth signal pathway switching device **1030**, to enable the 16-bit path in the sixth signal pathway switching device **1030** and disable/ignore the 32-bit bypass path **1022** coming from the third register **1020**. Thus, the output from first port **1004** and the second port **1006** are unrelated 16-bit packets of information.

[0043] If in one embodiment for example, a 32-bit point-to-point connection exist between the processor and the input-output component, then the arbiter **1002** gangs the output of the first port **1004** and the output of the second port **1006**. The arbiter **1002** sends a signal to the sixth signal pathway switching device **1030**. The arbiter's signal disables the 16-bit path in the sixth signal pathway switching device **1030** and enables the 32-bit bypass path **1022** coming from the third register **1020**. The arbiter **1002** also sends a signal to the first physical layer **1031**, the fourth signal pathway switching device **1026**, to enable the 32-bit bypass path **1022**. Thus, the output from first port **1004** and the second port **1006** are related 16-bit packets of information. In other words, the output from first port **1004** and the second port **1006** is a 32-bit packet of information. In order to keep the same transfer speeds, the arbiter **1002** also sends a signal to double the clocking speed that occurs in the registers. For example, the 32-bit packet of information in the third register **1020** is now clocked at 800 megahertz. 800 megahertz is twice the clock speed of when the 16-bit information transfer was occurring. In a similar manner, the arbiter **1002** can gang three ports together (not shown) to create a 48-bit connection in the outbound path.

[0044] In alternative embodiment, if three physical layers are linked to, for example, a second processor, then optionally the arbiter can be programmed to route the three related 16-bit packets

destined for the second processor through the respective components of each link and physical layer. Thus, the first 16-bit packet travels through the components of the first physical layer and first link layer. The second 16-bit packet travels through the components of the second physical and second link layer. The third 16-bit packet travels through the components of the third physical layer and second link layer. The arbiter changes the addressing header in the three 16-bit packets to convey to the second processor that these three 16-bit packets are related.

[0045] The invention is subject to various modifications and alternative forms. Specific embodiments thereof have been shown only by way of example. The connections between the processor and the devices may be, for example, 8-bit to 64-bit or more. The clock speeds may be, for example, one megahertz to one gigahertz or more. The registers may be 1-bit to 128-bits or more. Further, most functions performed by the electronic hardware components may be duplicated by software emulation. Similarly, the functionality of each layer, the protocol layer, the buffer layer, and the information transfer layer may be combined, for example, on a single layer or transported to another component. The invention should be understood to not be limited to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.